

Claims

[c1] What is claimed is:

1.A metal gate structure, comprising:

a gate oxide layer formed on a silicon substrate;

a doped silicon layer stacked on said gate oxide layer;

an ultra-thin titanium nitride barrier layer deposited on said doped silicon layer;

a tungsten nitride layer stacked on said ultra-thin titanium nitride barrier layer;

a tungsten layer stacked on said tungsten nitride layer;
and

a silicon nitride cap layer stacked on said tungsten layer.

[c2] 2.The metal gate structure according to claim 1 further comprising an oxide spacer formed on sidewall of said metal gate structure for protecting said tungsten nitride layer and said tungsten layer from oxidation.

[c3] 3.The metal gate structure according to claim 2 further comprising a silicon nitride spacer formed on said oxide spacer, and wherein said oxide spacer is liquid phase oxide spacer.

[c4] 4.The metal gate structure according to claim 1 wherein

said ultra-thin titanium nitride barrier layer is deposited using chemical vapor deposition (CVD) method and has a thickness of about 10~100 angstroms.

[c5] 5.The metal gate structure according to claim 1 wherein said ultra-thin titanium nitride barrier layer is deposited using atomic layer deposition (ALD), metal organic chemical vapor deposition (MOCVD) or Molecular Beam Epitaxial.

[c6] 6.The metal gate structure according to claim 1 wherein said doped silicon layer is doped polysilicon layer.

[c7] 7.A metal gate structure, comprising:
a gate oxide layer formed on a silicon substrate;
a doped silicon layer stacked on said gate oxide layer;
an metal barrier stack deposited on said doped silicon layer;
a tungsten nitride layer stacked on said metal barrier stack;
a tungsten layer stacked on said tungsten nitride layer;
and
a silicon nitride cap layer stacked on said tungsten layer.

[c8] 8.The metal gate structure according to claim 7 wherein said metal barrier stack is a triple-layer structure comprising a first metal layer, a second metal layer on said

first metal layer, and a third metal layer on said second metal layer.

- [c9] 9.The metal gate structure according to claim 8 wherein said first metal layer is made of a material selected from the group consisting of cobalt, titanium, nickel and tantalum.
- [c10] 10.The metal gate structure according to claim 8 wherein said second metal layer is made of a material selected from the group consisting of cobalt nitride, titanium nitride, nickel nitride and tantalum nitride.
- [c11] 11.The metal gate structure according to claim 8 wherein said third metal layer is made of a material selected from the group consisting of cobalt, titanium, nickel and tantalum.
- [c12] 12.The metal gate structure according to claim 7 wherein said metal barrier stack is a dual-layer structure comprising an upper metal layer and a lower metal layer.
- [c13] 13.The metal gate structure according to claim 12 wherein said upper metal layer is made of a material selected from the group consisting of cobalt nitride, titanium nitride, nickel nitride and tantalum nitride.
- [c14] 14.The metal gate structure according to claim 12

wherein said lower metal layer is made of a material selected from the group consisting of cobalt, titanium nickel and tantalum.